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ABSTRACT

The approach to finding a solution to underachievement in the area of problem solving has been of a fundamental psychological basis. Contrary to such a trend, this study takes into account the sociological processes of learning and transmission by both the family and the school. The research is based on Bernstein's theory in the sociology of education and uses as the main instruments of analysis his concepts of recognition and realization rules, his concepts of classification and framing, and his concept of pedagogic code. The data from this study were gathered using questionnaires and interviews. The intention was to see the extent to which students have recognition and realization rules at the micro context of problem solving within the broader context of learning in the science classroom. The sample consisted of 80 students from 4 classes of the 5-6 year of schooling in Lisbon (Portugal) taught by the same teacher in the subject Natural Sciences. The pupils were taught according to three pedagogic practices distinct in terms of power and control, from a practice characterized, in general, by weaker classifications and framings to a practice of stronger classifications and framings. An introduction is followed by descriptions of the sample, methodology, application of the instruments, process of evaluation, measure of recognition and realization, relation between the recognition and realization rules, characteristics of the students and school, a discussion, and conclusions. The results suggest some reasons for the difficulties many students encounter in problem solving situations and give possible directions to be taken into account in science pedagogic practice. (KR)

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RECOGNITION AND REALIZATION RULES IN LEARNING SCHOOL SCIENCE - A SOCIOLOGICAL APPROACH TO PROBLEM SOLVING

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RECOGNITION AND REALIZATION RULES IN LEARNING SCHOOL SCIENCE - A SOCIOLOGICAL APPROACH TO PROBLEM SOLVING

1. INTRODUCTION

This study is within a research project (Project ESSA - Sociological Studies of the Classroom) which aims at improving children's achievement in science education in both cognitive competencies and socio-affective dispositions. The whole research involves studies at the level of the school and the family. The study reported in this paper is focussed on the instructional discourse in the school, in particular in the area of problem solving. It continues other studies (Domingos, 1987, 1989 a, b; Peneda *et al*, 1990, 1991) which, contrary to the research in this area, mostly grounded in psychology and epistemology, is fundamentally based on sociology. These studies have shown that the disadvantaged children (social class, race, gender) are those who experience greater difficulty in applying knowledge to new situations, namely in problem solving.

The research is based on Bernstein's theory in the sociology of education and uses as main instruments of analysis his concept of code. As expressed by Bernstein, code is a regulator of the relation between contexts and as such it should generate principles which permit distinction between contexts and principles which lead to the production of texts adequate to each context. These principles are the *recognition rules* which create the means to distinguish between contexts and therefore to recognize the specificity which constitutes a context and the *realization rules* which regulate the creation and production of the specialized relations within the context.

In the conceptualization of the instruments of analysis we shall give the steps for the realization of the code: Marks the boundaries between contexts and selects the appropriate context

(has the recognition rules); selects the meanings adequate to the context and produces the text adequate to the context (has the realization rules). In our problem solving situation the child must distinguish between a context requiring the application of knowledge to new situations from a context requiring the showing of simple acquisition of knowledge. Having selected the relevant meanings the child then has to produce the text appropriate to the problematic question.

The intention of this study was to see the extent to which students have relevant recognition and realization rules at the micro context of problem solving within the broader context of learning in the science classroom. The data obtained will be analysed taking into account crucial social indicators, some of which more related to the family (social class, indicated by father's and mother's academic qualifications and occupations, race and gender) and some more related to the school (pedagogic practice and science achievement in high level cognitive competencies). The data will also be related to the student's cognitive level and to their coding orientation in a more general context, which is the object of another study (Fontinhas, *et al*, 1991).

2. SAMPLE

The sample was constituted by 80 students from four classes of the 5th-6th years of schooling (age 10^{-} - 12^{+}), taught by the same teacher in the subject Natural Sciences. The school contains a fundamentally working class population, constituted by white and black children, is located in the periphereal area of Lisbon.

Each one of the classes was organized to have an equal number of girls and boys. On the basis of the information available before the begining of the 5th year (given in the child's registration form), it was placed in each class an equal number of children of four social groups, from unskilled workers to

professionals at the highest level. This last group was the less represented (three children in each class), given the composition of the school population. In each class five black children were placed, the parents of which were reported to be unskilled workers. Within these criteria, the pupils were randomly distributed in each class.

The actual composition of the classes turned out to be different from the initially set. New information obtained during the course of the research modified to a certain extent the classes' social composition.

A sub-sample of 30 students (10 from each pedagogic practice - see § 3) were selected for most analysis of this study. It must be noted that all black children of this sub-sample are part of group 1, i.e. their fathers and mothers are illiterate and unskilled workers. There are no white children in this group. A pilot sample of 18 students (9 lower working class, including black and white children, and 9 middle class children) was also selected from school classes outside the research project.

The children are indicated by numbers and grouped according to the pedagogic practice they received (P_2: students 1-19; P_3: students 23-45; P_1: students 70-90).

3. METHODOLOGY

The pupils were taught according to three pedagogic practices (P_1, P_2, P_3), distinct in terms of power and control, from a practice (P_1) characterized, in general, by weaker classifications and framings to a practice (P_3) of stronger classifications and framings[1]. Two classes were submitted to pedagogic practice P_2, one to pedagogic practice P_1 and another one to pedagogic practice P_3.

The four classes were taught by the same teacher who changed

her pedagogic practice according to the criteria previously defined. The reason for this procedure was to make sure that the crucial variable the conceptual demand of the teacher was controlled[2].

Students' achievement in the instructional discourse was assessed in a 0-100 scale and was determined by the results of tests (the same test for the four classes), two tests in each one of the three terms of each academic year. These two tests gave the term's achievement which was reduced to a 1-4 scale (1: 0-24%; 2: 25-49%; 50-74%; 3: 75-100%). The achievement in the first term of the second year was used for the study described in this paper because it was closer in time to the empirical work (questionnaires and interviews). 60% of the questions of the tests assessed competencies which required a low level of abstraction, i.e. acquisition of knowledge - *cognitive low level competencies* (*A*) and 40% assessed competencies which required a high level of abstraction, i.e. use of knowledge to new situations - *cognitive high level competencies* (*U*)[3].

Four nominal indeces of social class were used, father's and mother's academic qualification and occupation. A composite of these indeces was used in the study described in this paper.

Data relating to the sociological characteristics were obtained through questionnaires to parents answered with the help of the researchers who, during the course of the broader study, visited the families and/or talked to them in the school. The reason for this procedure was to avoid errors when placing parents in the social groups. Given the small number of children we had to shorten both scales (academic qualification and occupation) to six categories[4]. For both race and gender we considered two categories (1-blacks; 2-whites; 1-girls; 2-boys). Cognitive development was measured according to Piaget's stages of development in a 1-6 scale[5], and using Task II constructed by Shayer (1979). This measure and a more complete account of its relations is the object of another study (Morais, Peneda, Medeiros, 1991).

Since in this study the students would have to show whether or not they were capable of recognizing the difference between the two micro-contexts of *A* and *U* situations and of producing the appropriate text to the latter, a questionnaire and a structured individual interview were developed to reveal these competencies[6]. According to theoretical expectations of the three pedagogic practices, the explicating of the differences between these two contexts would be high in P_3 and decrease in P_2, the differences being only implicit in P_1. The hypothesis was that children would be differentially prepared to recognize the two contexts and to produce the appropriate text to the *U* context.

The data obtained were related to social class, race, cognitive development, pedagogic practice and school achievement in *U* competencies. Given the small number of children, the analysis was fundamentally qualitative, although a correlational analysis was made and on occasions statistical tests appropriate for small samples were also used.

Given their extent and conceptual complexity it was decided not to include in this section, dedicated to the methodology, the description and application of the instruments and the processes of evaluation of the texts produced by children. These aspects will be given in the sections which follow. The text perhaps contains too many tables but these already represent a reduction of the total and they are needed to understand the text.

4. DESCRIPTION AND APPLICATION OF THE INSTRUMENTS

4.1 Identification of A and U questions

A questionnaire was constructed to evaluate the students' identification of two types of questions. It was constituted by ten questions about subject matters studied in the previous year (changes of physical state, properties of bodies, etc): five *A* questions (e.g. "In order to save money and also to avoid

polution, many countries are seriously thinking about using renewable energies. What are renewable energies?") and five *U* questions (e.g. "When we perspire, for example after running, we feel that our skin becomes cool. Why does perspiration gives this feeling of coldness?"). The size of *A* and *U* questions was similar.

The questionnaire was piloted with a greater number of questions from which selections were made, keeping those where students showed a better knowledge of the concepts. The language was also simplified. It was then applied to the whole sample in an evaluative context of the science classroom, similar to the usual tests' context. Before answering a short and simple explanation, using mainly an iconic language, was given to the four classes about *A* and *U* questions. With this procedure it was intended that all students would have a chance to answer, even those whose pedagogic practice did not make explicit that distinction.

The same questionnaire was given a second time, in the following weeks, to the sub-sample of 30 children, when the interview took place, this time in the form of a game. Cards with the iconic representation of *A* and *U* situations were used. They were asked not to be concerned about their previous answers. Afterwards the answers in the two moments were compared and the children were asked their idea of what *A* and *U* questions were about.

The data from the questionnaire in its two forms of application give a measure of the recognition rules which permit distinguishing between the two contexts *A* and *U*.

4.2 Production and identification of U answers

In this part of the interview the child was faced with the five *U* questions (problematic situations) of the questionnaire, one at a time. She was first asked to answer orally to them.

After that, she had to select, among three answers for each question, the most correct, the least correct and to explain her selections. Finally she is faced with two alternatives of how to think in order to answer. Cards with the appropriate text were always used.

Example

Question

When we perspire, for example after running, we feel that our skin becomes cool. Why does perspiration gives this feeling of coldness? Explain on the basis of the knowledge you have acquired about water's evaporation.

Answers

A - The water of the sweat lowers the temperature of the skin because that water takes out the energy needed for its evaporation.
B - The skin becomes cooler with the perspiration because of the sweat's evaporation.
C - Water's evaporation is the slow vaporization; the water passes slowly to the gaseous state as its particles are being released to the air.

The best way of thinking

1st - I would say how the sweat is constituted and also what I know about evaporation.
2nd - I would have to remember the phenomenon of evaporation and I would relate the need of energy with the cooling of the skin.

The steps of the interview are as followed:

(a) The card with the question is given to the child and she reads it aloud. She then was given time to read it silently.

(b) The child is asked to explicate what is required from her.

(c) Any doubt was clarified about the meaning of any term and also about the way the question was posed.

(d) If the child could not remember the concept(s) involved, a definition, in a very simple language, was given.

(e) The answer to the question was asked.

(f) The card with the three alternative answers is given, following a procedure similar to the one indicated in steps a), b), c).

(g) The child is asked to select the most correct answer and to explain the reason of her choice.

(h) The child is asked to select the least correct answer and to explain the reason of her choice.

(i) If the child showed difficulty in verbalizing her reasons, questions were made in order to obtain any explication.

(j) The card with the two alternatives about "the best way of thinking to solve the question" is given and the child is asked to select the one which is closer to her thought.

It should be noted that after being asked about the best answer, many children, *before* selecting it, immediately discarded the worst answer (an answer which would be appropriate to an *A* question). Only when this was not the case were they then asked about the worst answer.

The interview was first piloted with some pupils of the pilot sample, 4 middle class and 3 lower working class children. The immediate recognition of the least correct answer by the four middle class children gave some indication of the discriminatory power of this part of the interview. Some aspects of the former interview guide were discarded and they were not included in the final version above. Thus, for example, the indication "think aloud when you compare the alternatives" was taken out, since the majority of the children showed difficulty in verbalizing their thought. The tape recording of the interviews was also excluded because, given the conditions of the school, the interviews could not take place in a totally silent locale and the noise of the

playground interfered with the records. A grid with the "typical answers", obtained from the pilot study, was constructed to record the children's answers. Although this procedure led to some loss of information and some "interviewer's interpretations", the grid facilitated the conceptualization of the interviewees' answers.

The data from the interview made possible the analysis of the process of recognition and realization in the *A* and *U* contexts and so inferences could be made as to whether the children possessed the recognition and the realization rules for these two contexts.

5. PROCESSES OF EVALUATION OF THE TEXTS PRODUCED BY CHILDREN

5.1 Identification of A and U questions

As was said above, the first text produced by children was the written identification of *A* and *U* questions in a questionnaire with ten questions, by the students of the whole sample. The second text was the same identification in the form of a game by the sub-sample of thirty students. Each correct identification (*A* or *U*) was attributed 1 point. The scale of 0--10 was further reduced to 1-4[7].

The analysis of the questionnaire given to the whole sample provided data to obtain an index of recognition of *A* and *U* contexts, for all students. This index was used in the analyses of all variables involved in the global research referred to before and in which this study is included. For the thirty pupils of this study the index of identification was the result of the mean of correct identifications in the two contexts of the questionnaire and the interview (there are not, in general, large differences in the two occasions). These last values were used in this study as an indicator of the recognition rules in the two

contexts *A* and *U*.

5.3 Direct answering to U questions

As was explained previously, the children were faced with *U* questions and asked for a free answer. These answers were analysed using simultaneously the scales presented in figure 1. The categories in the scales were constructed on the basis of close reading of children's replies. There was no prompting of the children when they reply. The reliability was obtained by other researcher's checking.

(insert figure 1 about here)

In figure 2 we can see an example of the application of those scales.

(insert figure 2 about here)

The first type of answer in the figure could correspond to more than one situation - the child did not recognize the specific context or she did not remember the scientific knowledge needed and therefore she could not apply it even if she was capable to. In the second type of answer the child recognized the specific context but she was unable to produce the legitimate text and in the third situation the child recognized and realized.

The data obtained from this part of the interview gives a measure of recognition between the two discursive contexts, the non-academic and the academic and within this the sub-con-texts *A* and *U*. It also indicates realization of the legitimate text. This scaling instrument was also used to analyse the answers to *U* questions given by the students in the formal science tests. In that analysis account must be taken of the format of the test which may facilitate recognition and consequently the format

itself might trigger or orient the student to the use of school knowledge.

5.4 Selection of the most correct answer to an U question

For each *U* question there were three alternative answers from which the child would have to choose the best, i.e. the alternative which best explains the problematic situation on the basis of the concept(s) indicated in the question itself. For each question the three answers constituted always alternatives of the following type (see example in § 4.2):

Answer U^+ - Correct explanation on the basis of the concept(s) indicated in the question.

Answer U^- - Partial explanation on the basis of the concept(s) involved or explanation only on the basis of common sense knowledge.

Answer A - Definition of the concept(s) indicated.

The order of the answers was not the same for the five questions.

For computing the results of this part of the interview, we constructed the following scale for each question:

Selection U^+ - 2
Selection U^- - 1
Selection A - 0

The scale for all questions was then 0-10 (this scale was further reduced to 1-4: see note 7). A frequent selection U^+ (maximum 10 points for the five questions), even when it was not followed by a legitimate explanation (see paragraph below), will be considered as answers which reveal the possession of rules

which permit the frequent selection of the most correct alternative (see § 5.5). It was noticed that the child can select correctly quite often without being able to explain the reason for the selection. This may constitute an indicator of the presence of recognition and realization rules which the child is unable to formalize through a legitimate explanation. This seems an almost intuitive selection which may be attributed to the degree of cognitive development of the child. This stage of intuitive learning is a stage in which the child "already knows something" but is not yet able to structure that knowledge and organize it in concepts. Here the child will be unable to give a legitimate explanation which demands greater abstract forms of thought. It may be that the child has the thought but is unable to translate that thought in a grammatically and lexically appropriate way. The child possesses the first part of the realization rules - selects the appropriate text - but fails the second that is does not produce the appopriate text. This interpretation will gain more support if the child answered incorrectly to the previous part of the interview, where the child gave a free answer.

5.5 Explanation of the reason for the selection of an answer as the most correct

Every time the child chose an answer as the most correct, she was asked for an explanation for that choice. We constructed a 0--7 scale to analyse children's justifications which is presented in figure 3. This scale was further reduced to 1-4[8].

(insert figure 3 about here)

We believed that categories 5, 6 and 7, would not perhaps be reached by many children of these ages.

Given the fact that children's justifications were estimulated by the interviewer's questions, the child can, in each

question, go through some of the categories of the scale. (Figure 8). This was done in order that the child could give the better explanation she was capable to.

5.6 Selection and explanation of the least relevant answer

As was pointed out before, this selection was done, in many cases, when the children were asked for the best answer and, before chosing, they started by discarding the worst one. When the child selects the least correct alternative which is in fact an answer to an *A* question - definition, etc - and that rejection comes with a consistent explanation (e.g. that is not the answer because it is telling what it is rather than explaining), this answer is an indicator that the child recognized the two contexts *A* and *U*. The selection of the least relevant answer might be considered as an index of realization rules since the child is faced with texts appropriate in a smaller or greater extent. However we believe we are right in considering it within the recognition rules since during the course of the interview it was quite evident that some children distinguished between "what it is not" (the worst alternative) and "what can be" (the two other alternatives).

The correct selections and respective justifications were analysed according to the criteria presented in figure 4, in a scale 0-10. The incorrect selections were attributed 0. The scale was further reduced to 1-4 (see note 7).

(insert figure 4 about here)

5.7 Selection of "the best way of thinking"

The pilot study had hinted that children of this age have

difficulty in thinking aloud, possibly having difficulty in using the analytical process "to think the thought". We therefore opted to use cards, indicating two ways of thinking, and asked the students to select one of them. The alternatives given to the students for the selection of the "way of thinking to answer the question (U)" were of the following type (see example in § 4.2):

(1) "I would say what I knew about..., I would give a definition of...", which is appropriate for an *A* answer.

(2) "I would remember what I knew about... I would relate... and give an explanation on the basis of that knowledge", which is appopriate for an *U* answer.

The children did not show any difficulty in choosing one of these two alternatives. The results obtained in this selection were analysed together with the selection obtained for the best answer to give an index of consistency.

Let us consider the following examples:

(a) When selecting the alternative answer U^+ and the way of thinking *U*, the child produces the legitimate text and shows possession of realization rules.

(b) When selecting the alternative U^- and the way of thinking *U*, the child reveals possession of realization rules but she has some difficulty in producing the legitimate text, probably related with the knowledge involved.

(c) When selecting the alternative *A* and the way of thinking *U* this shows an inconsistency which may indicate a situation more extreme than the last.

(d) When selecting an answer *A* or *U* and the way of thinking *A*, the child does not possess the realization rules.

Figure 5 shows the categorizing in a 0-10 scale for the selection of the "way of thinking" taking into account the

selection of the alternative which answers best. The scale was further reduced to 1-4 (see note 7).

(insert figure 5 about here)

In determining an indicator of the non-existence of realization rules, it was attributed more weight to the selection of the "way of thinking *A*", because the results had shown a greater degree of difficulty in selecting the answers (resulting possibly of the specificity of the knowledge involved) than in that selection. Children who selected very often *U* answers, showing in some questions difficulties related to the knowledge involved, revealed to possess realization rules when they always selected the way of thinking *U*. We considered, therefore, that a stronger indication of the non-existence of realization rules would be a simultaneous selection of an answer *A* or *U* with the selection of the way of thinking *A* and to that combination was attributed 0. In fact, in choosing the alternative which answers the problem she was given and indicating afterwards that to solve the problem "she had to say what she knows about the subject", the child reveals that she does not possess the principles which apparently led her to the correct selection.

6. MEASURE OF RECOGNITION AND REALIZATION - TEXTS PRODUCED BY CHILDREN

6.1 Data obtained by simple indices

We have described the instruments and their application and also the processes of evaluation of the texts produced by children. We are now presenting the results of the empirical study, i.e. the texts produced by children, together with some interpretation. This section is organized to show first the texts related to recognition and afterwards the texts related to realization.

6.1.1 Identification of A and U questions

As was said before, the degree of identification for the thirty children was given by the mean of the correct identifications in two contexts, the questionnaire and the interview. The table in figure 6 presents the results. They show that 66,6% of the students were capable of identifying more than five questions correctly (categories 3 and 4).

(insert figure 6 about here)

6.1.2 Selection of the least correct answer and respective justification

The step of the interview which gave clearer indication of differential recognition between the contexts *A* and *U* was the selection of the least relevant answer. In rejecting in first place the definition (answer to an *A* question) the child distinguishes between those two contexts. The frequent rejection of *A* answers by some children, together with consistent justifications, makes it possible to distinguish between two groups of children, those who recognize and those who do not recognize what is required by the school. The table of figure 7 shows the results. It is clear that there is a great percentage of children (above 50%) who were unable to recognize the distinction between the two contexts *A* and *U*.

(insert figure 7 about here)

Comparing these interview results of the answers with those obtained through the questionnaire, and referring to the *A* questions, we can see that the percentage of children who identify correctly the *A* context is higher in the questionnaire than in the interview (66% as compared to 43%).

This may lead us to think that the recognition of the context

A in questions and answers do not share the same degree of difficulty. In face of a question it is easier for a child to recognize if she is asked a definition or if she is asked to use knowledge to new situations. In fact, the text of the question shows with common formats (typical grammatical structures) contexts which the student is accustomed to recognize, whether or not he/she knows or he/she does not know the knowledge required or the legitimate answer. The typical formats of *A* questions "tell what it is...", "give examples of...", "what do you mean..." are some examples. In the case of the choice of answers in the interview context the *A* answers also have typical formats. However, the *A* answer is in the context of an explanation whereas in the questionnaire the statement is only a simple question. This implies a higher variability of formats in the answers which may lead to a more difficult recognition.

So far we have argued that the identification is affected by the eliciting format of questions and answers. However, the children, when explaining the reason for the selection of a specific question as *A* or *U*, used expressions, considered as indicating non-recognition, for example:

. "This is *U* because one must think more to answer" (there is no explication of what an *U* question is).

. "This is *A* because I can tell the answer at once without having to think too much" (there is no explicit reason).

. "This is *U* because it tells about condensation which I do not know very well".

. "This is *U* because I have never heard about".

These texts show that despite the format of the question, many children pay attention directly to the knowledge, its degree of difficulty or even to the fact that they know or do not know the situation given.

When, in trying to identify a question as *A* or *U*, the child

only pays attention to the knowledge needed to solve the problem, the recognition can frequently be occasional or intuitive (non--formal). It is likely that the children will not yet have the recognition rules which, in a more comprehensive perspective, should also include the possibility of recognizing the question's format.

6.1.3 Direct answers to U questions

Here the children were presented with a problem solving question and asked to answer on the basis of a specific scientific concept. The results showed (Fontinhas, 1991) that:

- 60% of the answers were exclusively within common sense knowledge.
- Only 4% of the answers (6 in 150) correspond to the correct answer (CSO, A_3, U_3).
- 81% of the answers are U_0, i.e. do not make use of any school knowledge in the explanation.

It was noticed that the children, in general, did not show any hesitation in answering but did it as if they had shelved the "explain on the basis of the knowledge... you have acquired in the science classes". The answers sometimes consisted of descriptions of similar situations of their personal experience but they mainly consisted of repetition of the information contained in the question. Sometimes there were attempts of explanation but these were very seldom situated outside the confines of common sense explanations. For example:

- At home, when we are shut our breathing mists the window glasses.
- The window glasses get misty because it is cold and it is humid in the house.

. The breath hits the glass and, because it is cold, gets misty.

Even after it was pointed out that the explanation was not taking into account the school knowledge referred in the question, most children kept the first answers. Showing, in general, a certain fluency in the explanations at the level of common sense, it was noticed something like a barrier in preventing the verbalization of the explanation on the basis of the concept involved. On one hand, they explained the concept in their own words but on the other they solved the problem on the basis of common sense knowledge.

One can be led to think that, even though reminded of the concepts involved, the fact that some months had passed after the related learning, the factual experience needed for the construction of the concept had been forgotten and that concept was as if "not linked" and without meaning. This fact would have prevented the transference of learning and therefore its use, the answers tending to remain at the level of common sense. However, the analysis of the answers to questions of the same type (problem solving situations) selected from the tests usually done in the science classes, showed that the vast majority of children answered also at the level of common sense. Here it is not possible to justify this kind of answers only by children's forgetting of related knowledge. *U* questions in tests always follow *A* questions about the same scientific knowledge and the pupils, in general, answer the latter easily. On the other hand, this form of presentation of questions *A* and *U* in tests makes the boundaries between the two contexts *A* and *U* almost explicit.

We may therefore think that children of these ages are unable to produce correct answers to questions *U* for psycological reasons, namely the transference of learning or the verbalization of something they still only know at an intuitive level. According to Bruner, the child can very often reach solutions using the intuitive thought which would be impossible or more slowly done through the analytical thought involved in the *U*

questions. In the research line of the alternative conceptions many authors, within different perspectives, have shown that the common sense knowledge persists in spite of the school learning.

However as we will see the children had much less difficulty in producing a correct answer when they were asked to select among several alternative answers (see below). This may mean that, within the realization rules, they have the first part, i.e. the selection of the appropriate text but they fail to have the second, i.e. to produce the appropriate text. We can make a distinction between the child having a passive or an active realization competence. A passive competence is where the child can only choose the correct alternative, that is where the child can decode and an active realization competence where the child can produce the correct text, that is the child can encode the answer. It is possible to think that the school does not develop efficient strategies which lead the children to produce the correct text.

6.1.4 Selection of the most correct answer to an U question and respective justification

As has been said, one step of the interview consisted in selecting the most correct answer to a question justifying the selection. Figure 8 shows the results.

(insert figure 8 about here)

The analysis of the selections made by the children show that in a total of 150, only 21 correspond to selections of answers to *A* questions, i.e. definitions; 60 were U^- and 79 U^+. The analysis of the justifications show that none of the children reached category 4 (when the scale was reduced to four categories) and that only two children (6 and 13) were able to reach, for some questions, point 6 of the 0-7 scale.

As can be seen the answers *U* (U^+ and U^-) were frequently

selected by children. However the justifications which followed do not show possession of the realization rules. On the other hand, the children showed they were unable to produce, in a free answer, the legitimate texts for the same questions, which should include the selection of the knowledge required and its use in the explanations of problem solving situations. This leads us to conclude that many students marked the boundaries, selecting the context and also selecting the adequate meanings, but because the realization rules had not reached the degree of structuring required, they were unable to produce freely a text adequate to the context. This low level of structuring of the realization rules is revealed in the free answers, nearly all of which are common sense and in the justifications of the selections which seldom reached the threshold of legitimacy. It is interesting to notice that pedagogic practice P_3 leads to a relatively smaller gap between children when they had to select the best answer.

6.1.5 Relation between the texts "selects the best answer to U questions" and "selects the best way of thinking"

As was pointed out before, when we defined the criterion of evaluation of the text "selects the best way of thinking" it was considered more consistent its association with the "selection of the best answer". We have given previously the reasons for combining the selection of the best answer with the choice of the statement which was closer to the child's way of thinking. The results are presented in the table of figure 9.

(insert figure 9 about here)

It can be seen that a great percentage of selections (108 in 150 reveal consistency between the answer selected and the way of thinking and 31 reveal total inconsistency. If we consider this measure as an index of the possession of the realization rules, the results indicate that a great percentage of he children

possessed appropriate principles.

6.2 Data obtained by composite indices

So far we have been analysing separately the texts produced by children. Two of these texts, "identify *A* and *U* questions " and "choose the least adequate alternative and explain why", which were considered as indicators of the recognition of the *A/U* contexts, can now be combined in a composite index translating the degree of stability of the recognition rules accross contexts.

The texts produced in the other parts of the interview have to do with legitimate realizations. The combination of the respective indices in a composite index gives a measure of the possession (or degree of stability) of the realization rules. We are therefore assuming that realization rules underly the texts "select the best answer to a question and explain the reason for the selection" and "indicate the best way to think to answer this question (*U*)". For the construction of the composite indices we used the reduced scales of four degrees.

The diagram of figure 10 summarizes the relations between the indices of recognition and realization in order to determine the specific coding orientation in the micro *A/U* contexts in sciences.

(insert figure 10 about here)

Associating the values for the thirty students of the sub-sample in the various textual productions obtained through the questionnaire (identification of *A* and *U* questions in two contexts) and the interview, we have, for each student an index of recognition, an index of realization and a global index. This index can constitute a measure of the coding orientation in the specific *A* and *U* contexts .It should be pointed out that the two

simple indices for recognition are each based upon two scores and one of the three simple indices for realization is a combination of two scores.

The table of figure 11 shows these data for all students. The composite indices (recognition, realization) are rounded up means of the simple indices and the global indices (coding orientation) are rounded up means of the five simple indices of recognition and realization. They show a differential specific coding orientation, i.e. a differential recognition and realization between children in the *A* and *U* contexts in sciences.

(insert figure 11 about here)

It should be pointed out that in constructing the composite indices we did not score the direct answers to *U* questions since it was found out that virtually all children were unable to give those answers. This will be discussed in the conclusion.

7. RELATION BETWEEN RECOGNITION AND REALIZATION RULES IN THE A AND U CONTEXTS AND SOME CHARACTERISTICS OF STUDENTS/SCHOOL

7.1 Data

We measured the degree of recognition and realization of children, i.e. their coding orientation, in the *A* and *U* contexts in sciences and the data obtained show that there is differential recognition and realization. We now want to find out reasons for that differential competence, and we shall examine the relations between the findings and specific characteristics of the children, with respect to both the family and the school (social class, race, cognitive development, pedagogic practice and school achievement in *U* competencies).

In order to reach a more meaningful relation, we reduced the

scale of four categories, 1, 2, 3, 4, to two categories, either for recognition or for realization rules: 1 - "does not recognize" or "does not realize" (*NR*); 2 - "recognizes" or "realizes" (*R*). The thirty children were then grouped according to the following four groups of recognition/realization levels:

R/R - Recognize and realize
R/NR - Recognize and do not realize
NR/R - Do not recognize but realize
NR/NR - Do not recognize and do not realize

The table of figure 12 distributes the children by these four groups, indicating for each child social class, race, gender, cognitive development, pedagogic practice and achievement in *U* competencies in the science tests.

(insert figure 12 about here)

With the data expressed in the table, the means for each variable were computed and visually displayed according to the four categories recognition/realization. The histogram of figure 13 presents the results.

(insert figure 13 about here)

The correlations between the variables and the various indices (simple and composite) of the specific coding orientation were calculated (to simplify the table the simple indices are indicated by letters, the meaning of which can be seen in table of figure 10). Here the composite indices were calculated starting from the 1-4 scale rather than the reduced one (1-2) referred before. The table of correlations is presented in figure 14.

We did not present the relations for gender either in the histogram or in the correlations table because there were not relevant differences concerning this variable: the means were

similar in all groups and there was no correlation with any of the indices of the specific coding orientation, except for the identification of *A* and *U* questions (-.27) where girls performed better.

(insert figure 14 about here)

7.2 Discussion

The interpretation of the relations is going to be made mainly using the data as expressed in figures 12, 13, 14. The correlation table (figure 14) is likely to be misleading (see below) and therefore the discussion will take into account the raw data as they are given in figures 12 and 13. The discussion will start by looking at the relations of each one of the variables with the specific coding orientation and will procceed with a more comprehensive discussion of all variables involved that is the background of the child (social class, race, gender), cognitive development, pedagogic practice. The relation between the specific coding orientation and the science achievement in *U* competencies will also be analysed. Further, we will analyse the relation between the specific coding orientation in the *A* and *U* contexts and the coding orientation in a more general context.

The analysis of the relations show that the social class is highly correlated with recognition (.47), especially with the measure obtained through "the answer which adjusts less". It is not correlated with realization (.04). If we consider the group of children who can recognize and realize and the group who cannot recognize but can realize (figure 12), that is those who differ in recognition, we could see (test U Mann-Whitney) that there was a significant difference between these two groups in terms of social class. This gives more strength to the conclusion we could drew from correlation values and which indicates recognition as the fundamental failure of the lower social levels. However, social class is positively correlated with

realization through two of its indices, "explains the reason of the best answer" and "selects the best way of thinking to solve the question". It is at the level of selecting the best answer that social class does not seem to interfere. The highest correlation with social class is with child's hability to produce an explanation of the reason for the selection, that is to produce freely the legitimate text. On the whole, there is a relation (.30) between the specific coding orientation and social class which can also be read from the table of figure 12 and histogram of figure 13. We can conclude that children of lower social levels have more difficulty in recognizing the difference between the *A* and *U* contexts and in producing the legitimate text for the *U* context except in the simpler and isolated task of selection. They appear to lack the active competence of explaining.

Race is highly positively correlated with all the indices of recognition and realization and therefore with the specific coding orientation. We should not forget that all black children were part of social class 1, that is this variable is interfering in that relation. Thus, when we compare the two races we are comparing *also* the lowest social class with the other social groups. When we consider the total pattern of correlations between social class and recognition and realization on one side and race and recognition and realization on the other side, the crucial difference in this pattern occurs with the index of selecting the best answer (0.03 and 0.35). This indicates that black children of low social class have great difficulty in selecting an appropriate *U* answer. A more detailed analysis done through the data of figure 12 shows that only one black child is placed in the group of the children who both recognize and realize. In the interviews black children were uncapable of recognizing differences between the *A* and *U* contexts when they had to choose "the answer which adjusted less", whereas half of them were capable of recognition when this was measured through the identification of questions.

As we have referred before, the correlation between the specific coding orientation and gender is unexistent except for the index of recognition which refers to the identification of *A* and *U* questions, where girls performed better. On the other hand, the means are similar for the groups constructed and displayed in figure 12. On this basis, we would say that, in general, there was no differential performance of boys and girls, in the tasks which were taken as indices of recognition and realization. However, it is interesting to note that most girls of P_1 (4 out of 5) are in the group which can recognize and realize, which indicates that this practice is particularly favourable to girls independently of the social group and cognitive development.

There is also a positive correlation between the specific coding orientation of the children and their cognitive development (.24) which is also evident from data in figures 12 and 13 - children who can recognize and realize have the highest level of cognitive development and those who cannot do both operations have the lowest.

The correlation of the specific coding orientation with pedagogic practice shows only a trend (.15); this trend can be noticed between the pedagogic practice and the recognition and realization rules through their indices obtained respectively when "identifying questions *A* and *U*" and "selecting the best answer". However, a detailed analysis of the data in figure 12 shows that 7 children out of 10 of pedagogic practice P_3 can recognize and realize. For P_1 and P_2 the numbers are significantly lower. We had also seen that P_3 is the practice which led to a smaller gap between children when they selected the best answer. This shows a *clear relation with pedagogic practice which was not evident through correlation values.*

The highest correlation is between school achievement in *U* competencies and specific coding orientation (.45) either for recognition and realization rules and through all its indices. This is also evident in the histogram - children who can recognize and realize have the highest results in the science

class. However, this correlation is especially significant for recognition and, within the realization, for the selection of the best answer. It is important to notice that achievement in *U* competencies is, in general, low for all children (Morais *et al*, 1991 b). This may now be explained by the difficulty children have to produce a free answer, which constitutes the usual science tests' format for *U* questions. They do not have the active realization competence.

The clearest picture of the relationships between the variables is to be found in the histogram. The histogram (figure 13) shows clearly that social class is the most important of the variables in recognizing between the *A* and *U* contexts and in realizing the appropriate text to *U* situations. It can also be seen that the cognitive development of the child has also some importance. We have also seen that race and pedagogic practice constitute important factors. Students who have a better achievement in *U* competencies are those who can both recognize the two contexts and produce the appropriate text in the *U* context. They are likely to be high social class children, white, with higher cognitive development and submitted to a pedagogic practice where, among other characteristics (Fontinhas, 1991 and Antunes, 1991), explicit criteria of evaluation, namely in the *A* and *U* contexts had been given. They are not part of the lower working class, since only 4 children out of 16 belong to that level. The gender relation seems to be mediated by pedagogic practice, at least for girls.

It is now interesting to find the reasons for "discrepant" cases. If, for example, social class and race are factors influencing the coding orientation, i.e. the possession of recognition and realization rules, what is the reason why some working class and black children (15, 36, 75, 88) have these rules and some middle class (4, 6, 8) have not them. There are clearly other factors interfering. For space limitations we cannot enter into a detailed discussion of these aspects although data provided in other studies (Antunes, 1991; Fontinhas, 1991

and Fontinhas *et al*, 1991; Morais *et al*, 1991 a, b, e; Neves, 1991), can give to the interested reader some basis for grounded explanatory hypotheses. As an example, we will briefly refer to two cases.

Let us consider student 15 who is placed in social class 2. His father is a mason specialized in working with marbles and he is sent very often abroad by the enterprise where he works, he can speak english and in his free time he works as self-employed. Now let us consider student 36 who was subjected to a much more detailed analysis (Neves, 1991) and who is also placed in social class 2. His father is employed in a good restaurant having close contact with high-middle class people, he did a middle level course in hotel service, he can speak english, he learned latin when he was young (his parents wanted him to be a priest), he is interested in academic subjects especially in the area of sciences, he likes classical music, he showed to have an elaborated orientation, etc. It is not surprising that these two children have acquired in the family an elaborated orientation, perhaps even the pedagogic code of the school.

Finally we shall look at the relation between the specific coding orientation to science and a measure of the child's general coding orientation. This general coding orientation attempted to measure the child's orientation to choosing context independent definitions rather than context dependent, when given a series of non-social terms to define. Here we are making a comparison between competencies specific to science achievement and the child's general orientation. In order to create a valid basis for the comparison between the specific coding orientation and the general coding orientation, we used only the indices for recognition and the index for realization which closely corresponded to the tasks required in choosing the definitions in the context of the general coding orientation. On this basis we obtained a correlation of .37 between the specific coding orientation and the general coding orientation. This correlation was still higher with the composite index of recognition (.47).

On the other hand, the coding orientation studied in the general context does not correlate with social class whereas in the *A* and *U* micro-context of science classes it does correlate. This may be related to the fact pointed out above that the latter is both more specified and leads to a more subtle analysis. Further from the broader research we know that there is only a trend in the relation between the children's cognitive level and the identification of *A* and *U* questions (correlation .16); this trend is similar in this study. However, there is a significant relation (correlation .26) with the coding orientation in the general context referred, similar to the one found in this study. Thus taking account of the values for all indices we can be quite confident of this relation.

8. CONCLUSION

The aim of this study was to see the extent to which the students have recognition and realization rules at the micro--context of problem solving and to find out reasons which may underly their difficulties. The children answered a questionnaire and were individually interviewed, carrying out several tasks of recognition of the *A* and *U* contexts and of realization of the latter. With the data obtained in each step of the procedure we derived an index of recognition and an index of realization and on the basis of this we constructed composite indices of both recognition and realization rules and also a global index of coding orientation.

These indices were then related to some students' characteristics - social class, race, pedagogic practice, cognitive development and school achievement. The analysis also included the relation of the coding orientation given by this study with the coding orientation obtained in the general context of another study, as well as some inter-relations of both with social class, race, cognitive development.

The study showed that social class is the most important variable in determining the specific coding orientation in the *A* and *U* micro-contexts of the science classroom. However, it is at the level of recognition that social class seems to interfere deeply. It also interferes strongly at the level of the most complex tasks of realization. When children were simply asked to select the best answer the relation with social class disappears.

The study also showed that black children have, in all indices, lower degrees of recognition and realization. They showed especial difficulty in recognizing the two contexts when choosing the least relevant answer.

Perhaps the crucial finding for pedagogic change is the finding which shows the positive influence of P_3 on children's specific coding orientation. In fact the pedagogic practice, which in a more superficial analysis seems not to influence the recognition between the *A* and *U* contexts and to realize the appropriate text to the latter, showed to be a factor having a quite important weight in developing such competencies. The pedagogic practice P_3, where it was made more explicit the distinction between *A* and *U* situations and the adequate text to the latter, was the practice where a higher percentage of children showed to have recognition and realization rules. It is clear from this finding that, irrespective of the social background of the children and their individual cognitive development, the school can make a difference.

The finding about gender is also interesting because it shows that girls, irrespective of social class, cognitive development and perhaps race, develop better the recognition and realization competence within the pedagogic practice P_1. This supports other conclusions of the project (e.g. Morais *et al*, 1991 b).

What was said above show the mutual influence of the family and the school in developing the coding orientation of the school. Not surprisingly, the school achievement in *U* competencies is significantly correlated with the specific coding

orientation through all the indices considered, especially the recognition ones and the realization index about selecting the best answer. These findings are extremely important because they show that if the family socialization is crucial in developing the elaborated orientation, in which the school is institutionalized and needed for developing *U* competencies, the school can also contribute through a change in the modality of pedagogic code, that is in the modality of pedagogic practice. The explicating of the criteria of evaluation (strong framing), namely in the *A* and *U* contexts seems to be a crucial factor[10], although other factors absent in pedagogic practice P_3 (e.g. weak framing in the social relations of conduct, weak framing between groups of students - social class, race, gender) may be of great importance. If they were simultaneously present in the same pedagogic practice the students' achievement in the fundamental competence of problem solving could be higher. It is important to notice that some characteristics of P_3, which this pedagogic practice was not planned to have (Neves, 1991) but which existed in the *real* situation (Antunes, 1991; Fontinhas 1991), such as the weakening of external framing and of pacing, may have simultaneously with the strong framing in the evaluation criteria, an influence in the recognition and realization at the level of the *A* and *U* micro-contexts.

The study also showed some relation between the level of cognitive development and the coding orientation, a relation which also existed with the general measure of this orientation. Since we know from the broader study, carried out in the Project ESSA, that the cognitive development is significantly related with social class (Morais *et al*, 1991 c), we may infer that social class influence the acquisition of the pedagogic code of the school, namely in the area of problem solving, through both the acquisition of an elaborated orientation and the promotion of cognitive development. It is likely that social class influences the coding orientation (sociological) which in its turn influences the cognitive development (psychological). This is object of discussion in the paper cited above. The results

obtained in this paper lead us to think that lower social groups have special difficulty in distinguishing the context of problem solving from other contexts, that is they seem not to have the recognition rules at this level. Once these are given they can realize the legitimate text, although they again show difficulty in explicating this realization. It is important not to forget that virtually all students were uncapable of producing, in general, a free correct answer to the questions. They have a passive recognizing competence but they fail the active recognizing competence. This failure is higher for lower social class children because they also cannot explicate the realization.

These conclusions show the importance of a sociological analysis in trying to find out the most favourable characteristics of a pedagogic practice leading to develop the competence of problem solving. This constitutes a crucial competence to achieve a high level of scientific development by the students.

NOTES

1. See Neves (1991) and Morais and Neves (1991) where a detailed definition and description of the three practices is presented; this description includes agents, spaces, discourses. The teacher was expected to follow the pre-established criteria. See also Antunes (1991) and Fontinhas (1991) who, through the observation of the classes, characterized the practices *as they really occurred*.

2. Previous studies (Domingos, 1987, 1989 a, b) had shown the influence of the teacher's conceptual demand on the relation between social factors and students' achievement.

3. The detailed meaning of these two groups of competencies can be seen, for example, in Domingos (1987) and Morais *et al* (1991).

4. A detailed description of the scales for academic qualification and

occupation, and of their construction, can be seen in Neves (1991). A short version is the following:

Scale for academic qualifications:

Number of years of schooling was the main criterion for the scale of academic qualifications: 1 - Cannot read or write; 2 - completed primary school or attended a part of preparatory school; 3 - completed praparatory school (5th and 6th grades) or attended some years of secondary school (middle section 7th - 9th grades); 4 - took the 9th grade exams or completed a medium-level course after 6th grade; 5 - took the 11th grade exams (completed secondary school) or completed a medium-level course after 9th grade; 6 - completed a medium-level course after 11th grade or did some years of a university or obtained a university degree.

Scale for occupations:

The socio-economic status was the main criterion for the construction of this scale: 1 - Unskilled workers with no supervisory functions; 2 - unskilled workers with supervisory functions, skilled workers with or without supervisory functions, self-employed unskilled workers; 3 - self-employed skilled workers, small proprietors; 4 - non-manual emplyees in administration, commerce and other services without supervisory functions; 5 - non--manual employees in administration, commerce and other services with supervisory functions; 6 - self-employed or salaried professionals, administrators, managers.

5. The scale for cognitive development was the following: 1 - Pre--operational; 2A - early concrete; $2A^{+}$ - midconcrete; 2B - mature concrete; $2B^{+}$ - concrete generalization; 3A - early formal; $3A^{+}$ - midformal; 3B - late formal. The highest stage reached by the children in this study was 3A; the scale was then reduced to 1-6.

6. For space limitations we are only giving some examples of the questions and steps of the questionnaire and of the interview. The complete versions can be seen in Fontinhas, 1991.

7. Reduction of 0-10 scale to 1-4: 1(0, 1, 2); 2 (3, 4, 5); 3 (6, 7, 8); 4 (9-10).

8. Reduction of 0-7 scale (0-35) to 1-4: 1(0-8); 2 (9-17); 3 (18-26); 4 (27-35).

9. Common sense examples are not given in the table because they are too long.

10. A suggestion of the influence of this factor had been given by the study carried out by Domingos 1987, 1989 b).

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SCALE OF ANALYSIS FOR COMMON SENSE ANSWERS (CS) (degree of explanation on the basis of common knowledge)	
CS0	Does not use common sense to explicate the problematic situation
CS1	Repeats the information contained in the question; describes only the situation without explaining; explains using non-related or inconsistent common knowledge
CS2	Points out the fundamental facts but does not explain (does not make explicit any explanation)
CS3	Explains coherently but making only use of common knowledge

SCALE OF ANALYSIS FOR SCHOOL KNOWLEDGE (A) (degree of selection of the knowledge needed to the explanation)	
A0	Does not select school knowledge to explain
A1	Selects inadequate school knowledge
A2	Selects some school knowledge
A3	Selects all school knowledge needed to the explanation

SCALE OF ANALYSIS FOR USE OF SCHOOL KNOWLEDGE (U) (degree of explanation on the basis of the school knowledge selected)	
U0	Does not use the school knowledge to explain
U1	Tries to explain on the basis of school knowledge but is uncapable of explicating its transference or it is inadequately done
U2	Explains using the school knowledge but that is only partially done
U3	Explains totally on the basis of school knowledge selected

Figure 1 - *Scales of categorization for the analysis of direct answers to U questions.*

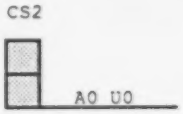
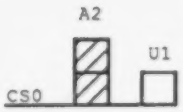
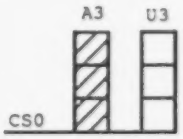
	Explains only on the basis of common sense knowledge; does not select school knowledge to solve the question and consequently does not use that knowledge.
	Answers using only school knowledge; selects some of the related knowledge trying to solve the question on its basis without succeeding.
	Answers using only school knowledge; selects the adequate knowledge and solves the question on the basis of that knowledge.

Figure 2 · *Examples of the application of the scales of categorization for the analysis of direct answers to U questions.*

CODING ORIENTATION		MAIN CHARACTERISTIC OF STUDENT'S JUSTIFICATION	EXAMPLES
Does not have realization rules	0	Does not answer or answers inconsistently	
	1	Justifies by progressive exclusion of statements, excluding alternatives for not legitimate reasons	Because: I do not agree with the statement(s); it has incorrect words; it has a confusing writing; I do not understand well
	2	Just repeats the information contained in the alternative (textually or putting it in he/ /she own words)	
	3	Gives personal or common sense reasons	Because: it has more correct words; it is as in the book9
May or may not have	4	Compares the alternatives in general terms but does not specify	Because: it is the most complete; it is the most correct; it is the one wich explains better; it is the one which answers the question better
Has realization rules	5	Compares and specifies the amout of different knowledge present in the alternatives	Because besides telling about air pressure it also tells about air expansion
	6	Compares and explicates the degree of explanation of the alternatives	Because it is not limited to telling about evaporation but also explains that this is caused by the energy obtained from the skin
	7	Compares and explicates the degree to which the alternative is adequate to the question	Because it is not limited to explaining the phenomenon but this is done more in accordance with the question, i.e.... (explication is given)

Figure 3 - *Scale of categorization of student's justifications for the selection of the most correct answer.*

DEGREE OF RECOGNITION		Scale	EXAMPLES OF JUSTIFICATIONS GIVEN BY STUDENTS
Explicates the recognition	+	2	Because: it is telling what is condensation rather than explaining the reason why the window glass is misty; it is answering the question "what is condensation".
May have recognized but does not explicate that recognition	±	1	Because it does not answer well to the question.
Does not recognize	-	0	Because: it is not complete; it has a complex redaction; what it tells is not quite correct, etc.

Figure 4 - *Categorizing scale of the justifications for the selection of the least relevant answer.*

SELECTION OF THE MOST CORRECT ANSWER TO QUESTION U	SELECTION OF THE "BEST WAY OF THINKING" TO SOLVE QUESTION U	Scale
Answer U^+	"Way of thinking" U	2
Answer U^-	"Way of thinking" U	
Answer A	"Way of thinking" U	1
Answer A or U	"Way of thinking" A	0

Figure 5 - *Categorizing scale for the "selection of the best way of thinking" together with the selection of the best answer.*

P2		P3		P1	
STUDENTS	CATEGORIES 1-4	STUDENTS	CATEGORIES 1-4	STUDENTS	CATEGORIES 1-4
1	3	23	3	70	4
4	3	27	3	72	3
6	4	29	3	73	2
8	2	32	3	75	3
10	3	34	2	79	2
13	2	36	3	81	3
15	3	38	3	82	2
17	2	40	4	84	3
18	3	43	2	88	3
19	2	45	3	90	2
MEANS	2.7		2.9		2.7

Figure 6 - *Students' positive identifications of A and U questions.*

STUDENTS	ALTERNATIVE DISCARDED					JUSTIFICATION					Total	CATEGORIES 1-4	RECOGNITION
	1	2	3	4	5	1	2	3	4	5			
1	U^+	U^-	U^+	A	A	-	-	-	-	-	0	1	NR
4	U^-	U^-	U^+	A	U^-	-	-	-	-	-	0	1	NR
6	A	A	A	A	A	+	+	+	+	+	10	4	R
8	U^+	U^-	U^-	U^+	U^+	-	-	-	-	-	0	1	NR
10	U^-	A	A	U^-	U^+	-	+	-	-	-	2	1	NR
13	A	A	A	A	U^-	+	+	±	±	-	6	3	R
15	A	A	A	A	A	-	-	+	+	+	6	3	R
17	A	U^-	A	A	A	±	-	+	-	+	5	2	NR
18	A	A	A	A	A	+	+	+	+	+	10	4	R
19	A	A	U^+	U^-	U^+	±	-	-	-	-	2	1	NR
23	U^-	U^-	A	A	A	-	-	±	±	±	3	2	NR
27	A	A	U^+	A	A	+	+	-	+	+	8	3	R
29	A	A	A	A	A	+	+	+	+	+	10	4	R
32	A	A	A	A	A	±	+	±	±	+	7	3	R
34	U^+	A	U^-	U^-	U^-	-	±	-	-	-	1	1	NR
36	A	A	U^-	A	A	+	+	-	+	±	7	3	R
38	A	U^-	U^+	U^+	A	+	-	-	-	±	3	2	NR
40	A	A	A	A	A	+	+	+	+	+	10	4	R
43	A	U^-	A	U^-	U^-	±	-	-	-	-	1	1	NR
45	A	A	U	U	A	-	-	±	-	-	1	1	NR
70	U^+	U^-	A	U^-	U^+	-	-	-	-	-	0	1	NR
72	A	A	A	A	A	+	+	+	+	+	10	4	R
73	A	A	U^+	A	A	+	+	-	+	-	6	3	R
75	A	U^+	U^+	U^+	A	±	-	-	-	+	3	2	NR
79	A	A	U^+	A	A	±	±	-	-	±	3	2	NR
81	U^+	U^+	U^+	U^-	A	-	-	-	-	-	0	1	NR
82	U^+	U^-	U^+	U^-	U^+	-	-	-	-	-	0	1	NR
84	A	A	A	A	A	+	+	+	+	+	10	4	R
88	U^-	A	U^-	A	A	-	+	-	+	+	6	3	R
90	U^+	U^+	A	U^-	U^+	-	-	-	-	-	0	1	NR

Figure 7 - *Selection of the least correct answer to a U question together with respective justification (Students are grouped according to pedagogic practices, P2, P3, P1. R - recognize or realize; NR - do not recognize or do not realize).*

STUDENTS	SELECTS THE BEST ANSWER										Total	Categories (1-4)	EXPLAINS THE REASON FOR THE BEST ANSWER	Total	Categories (1-4)
	1	2	3	4	5	Points 1	2	3	4	5					
1	U⁻	A	A	U⁺	U⁻	1	0	0	2	1	4	2	2; 1->2; 1->2; 0->1; 1->2	9	2
4	U⁺	U⁺	A	U⁺	A	2	2	0	2	0	6	3	2->4; 1->3; 1->4; 2->3; 4	19	3
6	U⁺	U⁺	U⁺	U⁺	U⁺	2	2	2	2	2	10	4	3->6; 2->4; 4; 5; 6	25	3
8	U⁻	A	A	A	A	1	0	0	0	0	1	1	1->3; 1->4; 1->5; 0; 2	14	2
10	U⁺	U⁺	U⁻	U⁺	U⁻	2	2	1	2	1	8	3	5; 1->2->4; 0->1; 1->2; 2	14	2
13	U⁺	U⁺	U⁺	U⁺	U⁺	2	2	2	2	2	10	4	2->4;5; 5; 5; 6	25	3
15	U⁺	U⁺	U⁺	U⁺	U⁺	2	2	2	2	2	10	4	4; 1->2; 2; 0; 2->3	11	2
17	U⁻	U⁺	U⁻	U⁺	U⁻	1	2	1	2	1	7	3	2->4; 2->4; 2->4; 2; 2	16	2
18	U⁺	U⁻	U⁻	U⁺	U⁺	2	1	1	2	2	8	3	4; 4; 5; 4; 3	20	3
19	U⁻	U⁺	A	A	U⁻	1	2	0	0	1	4	2	0; 2->3; 2; 0; 2	7	1
23	U⁺	U⁺	U⁺	U⁻	U⁺	2	2	2	1	2	9	4	4->5; 4; 2->4; 4; 2->4; 4	21	3
27	U⁺	U⁻	U⁻	U⁻	U⁺	2	1	1	1	2	7	3	2->3; 4; 3; 2; 0	12	2
29	U⁺	U⁻	U⁻	U⁺	U⁺	2	1	1	2	2	8	3	2->4; 3; 1->3; 1->4; 4	18	3
32	U⁺	U⁺	U⁻	U⁺	U⁻	2	2	1	2	1	8	3	2->4; 2->4; 3->4->5; 5; 2	20	3
34	U⁻	U⁺	U⁺	A	A	1	2	2	0	0	5	2	3; 4; 3; 4; 3	17	2
36	U⁺	U⁺	U⁺	U⁺	U⁺	2	2	2	2	2	10	4	4; 4->5; 4; 4; 4	21	3
38	U⁻	U⁺	A	U⁻	U⁻	1	2	0	1	1	5	2	4; 1->4; 4; 1->4; 2	18	3
40	U⁺	U⁺	U⁻	U⁻	U⁺	2	2	1	1	2	8	3	4; 4; 2; 1; 4	15	2
43	U⁻	A	U⁺	U⁺	U⁺	1	0	2	2	2	7	3	2->4; 2; 2; 0; 2	10	2
45	U⁻	U⁻	U⁻	U⁺	U⁺	1	1	1	2	2	7	3	1; 1; 4; 5; 4->5	16	2
70	U⁻	U⁺	U⁺	A	A	1	2	2	0	0	5	2	1->2; 1->2->3; 1->2; 1->2; 1->2	11	2
72	U⁺	U⁻	U⁻	U⁺	U⁺	2	1	1	2	2	8	3	4; 4; 4; 4; 4	20	3
73	U⁻	U⁺	U⁻	U⁺	U⁺	1	2	1	2	2	8	3	1->4; 1->2; 1->2; 2->5; 2->4	17	2
75	U⁺	U⁻	U⁻	U⁻	U⁺	2	1	1	1	2	7	3	4; 4; 4; 4; 4	20	3
79	U⁻	U⁺	A	U⁺	U⁺	1	2	0	2	2	7	3	5; 5; 4; 2->4->5; 4->5	24	3
81	U⁻	U⁻	U⁻	A	U⁺	1	1	1	0	2	5	2	1->2; 1->2; 1->2; 1->4; 1->2	12	2
82	U⁻	U⁺	U⁻	A	A	1	2	1	0	0	4	2	1->2; 1->2; 1->2; 1->2; 1->2	10	2
84	U⁻	U⁺	U⁻	U⁺	U⁺	1	2	1	2	2	8	3	1; 5; 1->3; 5; 5	19	3
88	U⁺	U⁺	U⁺	U⁻	U⁺	2	2	2	1	2	9	4	4; 4; 5; 4; 5	22	3
90	U⁻	U⁻	U⁻	U⁺	A	1	1	1	2	0	5	2	0->1; 1->2; 1->2; 1->2; 4; 2	11	2

Figure 8 - *Selection of the most correct answer to a U question and respective justification (students are grouped according to pedagogic practices, P2, P3, P1).*

STUDENTS	SELECTS THE "BEST WAY OF THINKING"/SELECTS THE BEST ANSWER					Points					Total	Categories (1-4)
	1	2	3	4	5	1	2	3	4	5		
1	A/U$^-$	A/A	A/A	A/U$^+$	U/U$^-$	0	0	0	0	2	2	1
4	U/U$^+$	U/U$^+$	U/A	U/U$^+$	A/A	2	2	1	2	0	7	3
6	U/U$^+$	U/U$^+$	U/U$^+$	U/U$^+$	U/U$^+$	2	2	2	2	2	10	4
8	U/U$^-$	U/A	U/A	U/A	A/A	2	1	1	1	0	5	2
10	U/U$^+$	U/U$^+$	U/U$^-$	U/U$^+$	A/U$^-$	2	2	2	2	0	8	3
13	A/U$^+$	U/U$^+$	U/U$^+$	U/U$^+$	U/U$^+$	0	2	2	2	2	8	3
15	U/U$^+$	A/U$^+$	U/U$^+$	U/U$^+$	U/U$^+$	2	0	2	2	2	8	3
17	U/U$^-$	A/U$^+$	U/U$^-$	U/U$^+$	U/U$^-$	2	0	2	2	2	8	3
18	U/U$^+$	U/U$^-$	U/U$^-$	U/U$^+$	U/U$^+$	2	2	2	2	2	10	4
19	U/U$^-$	U/U$^+$	A/A	U/A	U/U$^-$	2	2	0	1	2	7	3
23	U/U$^+$	A/U$^+$	U/U$^+$	U/U$^-$	U/U$^+$	2	0	2	2	2	8	3
27	U/U$^+$	U/U$^-$	U/U$^-$	U/U$^-$	U/U$^+$	2	2	2	2	2	10	4
29	U/U$^+$	U/U$^-$	U/U$^-$	U/U$^+$	U/U$^+$	2	2	2	2	2	10	4
32	U/U$^+$	U/U$^+$	A/U$^-$	U/U$^+$	U/U$^-$	2	2	0	2	2	8	3
34	A/U$^-$	A/U$^+$	A/U$^+$	A/A	A/A	0	0	0	0	0	0	1
36	U/U$^+$	U/U$^+$	U/U$^+$	U/U$^+$	U/U$^+$	2	2	2	2	2	10	4
38	U/U$^-$	U/U$^+$	U/A	A/U$^-$	U/U$^-$	2	2	1	0	2	7	3
40	U/U$^+$	U/U$^+$	A/U$^-$	U/U$^-$	U/U$^+$	2	2	0	2	2	8	3
43	U/U$^-$	U/A	U/U$^+$	U/U$^+$	U/U$^+$	2	1	2	2	2	9	4
45	A/U$^-$	U/U$^-$	U/U$^-$	A/U$^+$	U/U$^+$	0	2	2	0	2	6	3
70	U/U$^-$	U/U$^+$	U/U$^+$	U/A	A/A	2	2	2	1	0	7	3
72	U/U$^+$	U/U$^-$	U/U$^-$	U/U$^+$	U/U$^+$	2	2	2	2	2	10	4
73	U/U$^-$	U/U$^+$	U/U$^-$	U/U$^+$	U/U$^+$	2	2	2	2	2	10	4
75	U/U$^+$	U/U$^-$	U/U$^-$	U/U$^-$	A/U$^+$	2	2	2	2	0	8	3
79	U/U$^-$	U/U$^+$	A/A	A/U$^+$	A/U$^+$	2	2	0	0	0	4	2
81	U/U$^-$	U/U$^-$	U/U$^-$	U/A	U/U$^+$	2	2	2	1	2	9	4
82	U/U$^-$	A/U$^+$	U/U$^-$	U/A	A/A	2	0	2	1	0	5	2
84	U/U$^-$	U/U$^+$	U/U$^-$	U/U$^+$	U/U$^+$	2	2	2	2	2	10	4
88	U/U$^+$	U/U$^+$	U/U$^+$	U/U$^-$	U/U$^+$	2	2	2	2	2	10	4
90	A/U$^-$	U/U$^-$	U/U$^-$	A/U$^+$	U/A	0	2	2	0	1	5	2

Figure 9 - *Selection of the "best way of thinking" together with selection of the best answer (students are grouped according to pedagogic practices P2, P3, P1).*

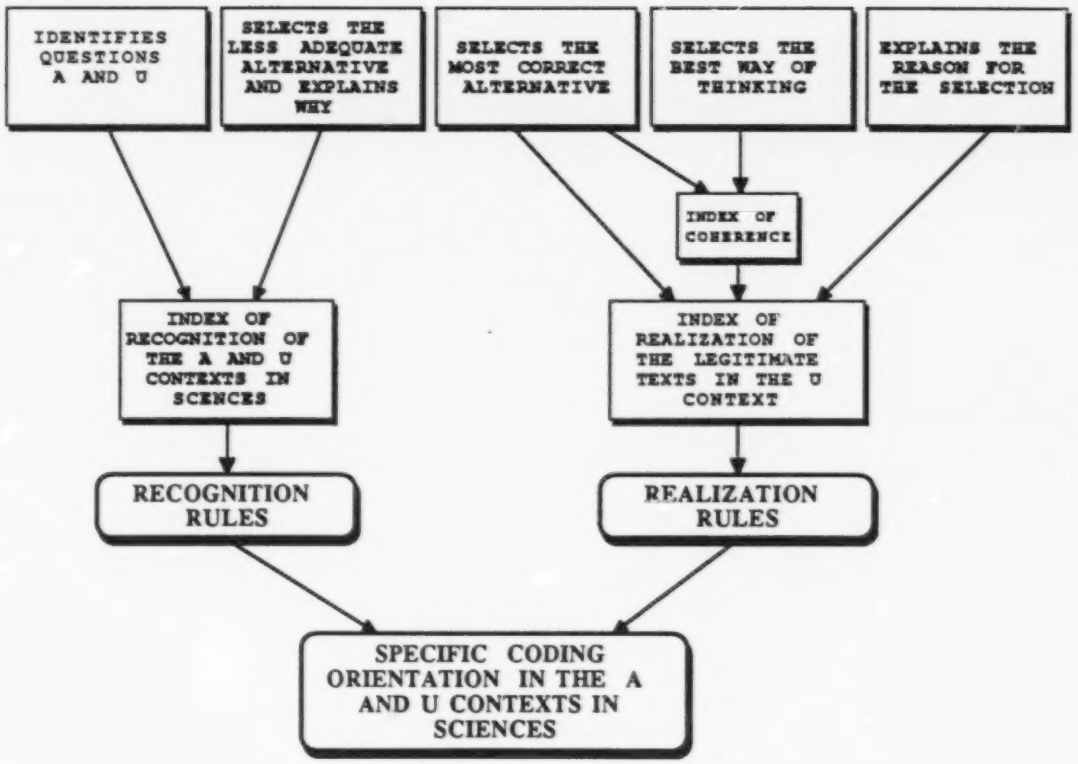

IDENTIFIES QUESTIONS A AND U
SELECTS THE LESS ADEQUATE ALTERNATIVE AND EXPLAINS WHY
SELECTS THE MOST CORRECT ALTERNATIVE
SELECTS THE BEST WAY OF THINKING
EXPLAINS THE REASON FOR THE SELECTION
INDEX OF COHERENCE
INDEX OF RECOGNITION OF THE A AND U CONTEXTS IN SCIENCES
INDEX OF REALIZATION OF THE LEGITIMATE TEXTS IN THE U CONTEXT
RECOGNITION RULES
REALIZATION RULES
SPECIFIC CODING ORIENTATION IN THE A AND U CONTEXTS IN SCIENCES

Figure 10 - *Relations between the indices of recognition and realization to determine the specific coding orientation in the A/U contexts in sciences.*

Students	Identifies questions A and U in 2 contexts (mean)	Selects the worst answer (answer for a question A)	RECOGNITION RULES	Selects the best answer	Explains why	Selects the best way of thinking/ /selects the best answer	REALIZATION RULES	SPECIFIC CODING ORIENTATION
	A	B		C	D	E		
1	3	1	2 NR	2	2	1	2 NR	2
4	3	1	2 NR	3	3	3	3 R	3
6	4	4	4 R	4	3	4	4 R	4
8	2	1	2 NR	1	2	2	2 NR	2
10	3	1	2 NR	3	2	3	3 R	2
13	2	3	3 R	4	3	3	3 R	3
15	3	3	3 R	4	2	3	3 R	3
17	2	2	2 NR	3	2	3	3 R	2
18	3	4	4 R	3	3	4	3 R	3
19	2	1	2 NR	2	1	3	2 NR	2
23	3	2	3 R	4	3	3	3 R	3
27	3	3	3 R	3	2	4	3 R	3
29	3	4	4 R	3	3	4	3 R	3
32	3	3	3 R	3	3	3	3 R	3
34	2	1	2 NR	2	2	1	2 NR	2
36	3	3	3 R	4	3	4	4 R	3
38	3	2	3 R	2	3	3	3 R	3
40	4	4	4 R	3	2	3	3 R	3
43	2	1	2 NR	3	2	4	3 R	2
45	3	1	2 NR	3	2	3	3 R	2
70	4	1	3 R	2	2	3	2 NR	2
72	3	4	4 R	3	3	4	3 R	3
73	2	3	3 R	3	2	4	3 R	3
75	3	2	3 R	3	3	3	3 R	3
79	2	2	2 NR	3	3	2	3 R	2
81	3	1	2 NR	2	2	4	3 R	2
82	2	1	2 NR	2	2	2	2 NR	2
84	3	4	4 R	3	3	4	3 R	3
88	3	3	3 R	4	3	4	4 R	3
90	2	1	2 NR	2	2	2	2 NR	2

Figure 11 · *Values for the thirty students of the sub-sample in the texts produced and in the composite indices - recognition rules, realization rules and specific coding orientation (Students are grouped according to pedagogic practices P2, P3, P1. R - recognize or realize; NR - do not recognize or do not realize).*

CODING ORIENTATION	Students	Social class	Race	Gender	Cognitive Development	Pedagogic Practice	Achievement (U competencies)
							Means
RECOGNIZE AND REALIZE (R/R)	6	3	2	1	4	P2	3
	13	3	2	2	4	P2	2
	15	2	2	2	3	P2	3
	18	6	2	2	3	P2	2
	23	4	2	2	2	P3	2
	27	3	2	2	2	P3	2
	29	5	2	1	4	P3	2
	32	3	2	1	2	P3	2
	36	2	2	2	4	P3	3
	38	4	2	2	4	P3	3
	40	3	2	1	4	P3	4
	72	5	2	2	5	P1	2
	73	5	2	1	3	P1	1
	75	1	1	1	2	P1	2
	84	5	2	1	3	P1	2
	88	2	2	1	6	P1	3
(R/NR)	70	6	2	1	4	P1	2
DO NOT RECOGNIZE BUT REALIZE (NR/R)	4	4	2	1	3	P2	2
	10	2	2	1	3	P2	1
	17	1	1	2	4	P2	2
	43	1	1	1	2	P3	2
	45	2	2	2	2	P3	2
	79	2	2	2	5	P1	2
	81	1	1	2	2	P1	2
DO NOT RECOGNIZE NOR REALIZE	1	2	2	1	3	P2	2
	8	5	2	1	3	P2	2
	19	1	1	2	4	P2	2
	34	1	1	2	1	P3	1
	82	2	2	2	2	P1	2
	90	2	2	1	3	P1	2

Figure 12 - *Distribution of students (and their characteristics) according to four levels of recognition and realization in the A and U contexts in sciences.*

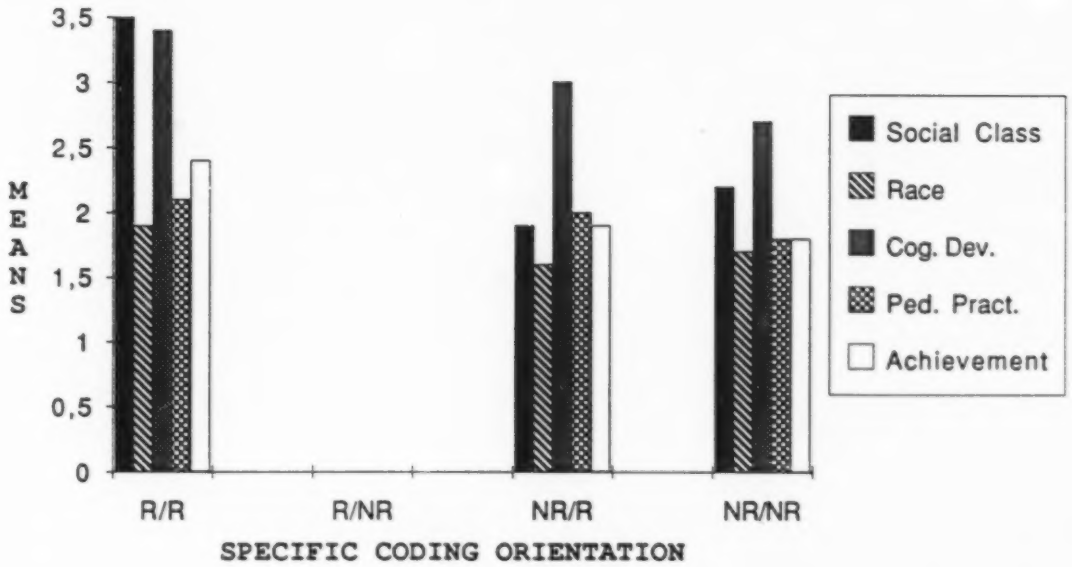


Figure 13 - *Means of characteristics of students according to four levels of recognition and realization in the A and U contexts in sciences.*

STUDENTS' CHARACTERIST.	RECOGNITION			REALIZATION				SPECIFIC CODING ORIENTATION
	A	B	Rec.	C	D	E	Real.	
Social Class	0.23	0.34	0.47	0.03	0.34	0.24	0.04	0.30
Race	0.22	0.45	0.39	0.35	0.39	0.25	0.33	0.39
Cognitive Development	0.17	0.40	0.33	0.27	0.29	0.26	0.36	0.24
Pedagogic Practice	0.13	0.07	0.05	0.16	0.00	0.00	0.15	0.15
Achievement (U competencies)	0.52	0.42	0.42	0.32	0.22	0.22	0.44	0.45

Figure 14 - *Correlations between students' characteristics and specific coding orientation (simple and composite indices).*